FLYWHEEL REGENERATIVE BREAKING SYSTEM

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ABSTRACT

The study proposed in this thesis aims to model a Flywheel Regenerative Breaking System (f-RBS). F-RBS is based on a simplified mechanical model which is meant to remove energy conversion losses while storing the power of rotational braking. f-RBS consists of a flywheel for the electricity storage system (ESS) and a V-belt Continuously Variable Transmission CVT. Mathematical models of friction analysis are derived. A model of f-RBS is designed with Solidworks™. Results showed that using the f-RBS concept could significantly influence the recycling of braking power waste and provide additional energy.

INTRODUCTION

For many years, energy experts have been arguing that the turning point for renewable energy is on the way and that soon the day will come when solar panels cover the roofs of our homes, and our roads are full of electric and hybrid cars. The alternative energy industry - has made significant strides in cutting costs - is now a prominent place in global energy. Fossil fuels are still playing a critical role, but the growing enthusiasm for alternative energy suggests that oil and gas will continue to decline against green energy sources in the coming years. [1]

Renewable energy has significant investment financial benefit related to profitability, solvency, and growth ability such as; return on total assets, operating profit ratio, gross profit margin on principal business, tangible asset net debt ratio, current liabilities ratio, profit to cost ratio, debt to assets ratio, current ratio, quick ratio, main business increasing rate, net capital increasing ratio, and total assets growth rate. Renewable energy has significant investment economic benefit related to economic net present value, economic internal rate of return, and degree of technology innovation investment. Renewable energy has significant investment social benefit related to natural environment, social economy, and social development such as; save natural resources, reduce environment pollution, drive relevant industries development, promote economic development, land value increment benefit, employment promotion, improve investment environment, and industry general benefits. [2]

FLYWHEEL REGENERATIVE BRAKING SYSTEM

Regenerative braking system is a system to store kinetic energy of a traveling vehicle while deaccelerating. Flywheel Regenerative Braking System stores the kinetic energy while the vehicle is traveling minimum energy is needed to move the vehicle. Brakes are ordinarily used to reduce velocity of the vehicle ; in contrast, while riding uphill, it becomes too tiresome to move the vehicle. If a vehicle is provided with f-RBS then the driver can have an additional source of power that can be used at his will.

The kinetic energy is not fully utilized whenever brakes are applied. It gets converted into heat energy due to friction between rim and brake pad. Vehicles equipped with RBS are able to utilize kinetic energy under braking the vehicle. Kinetic energy utilizes mechanisms which can be used to give the vehicle additional power. [3]

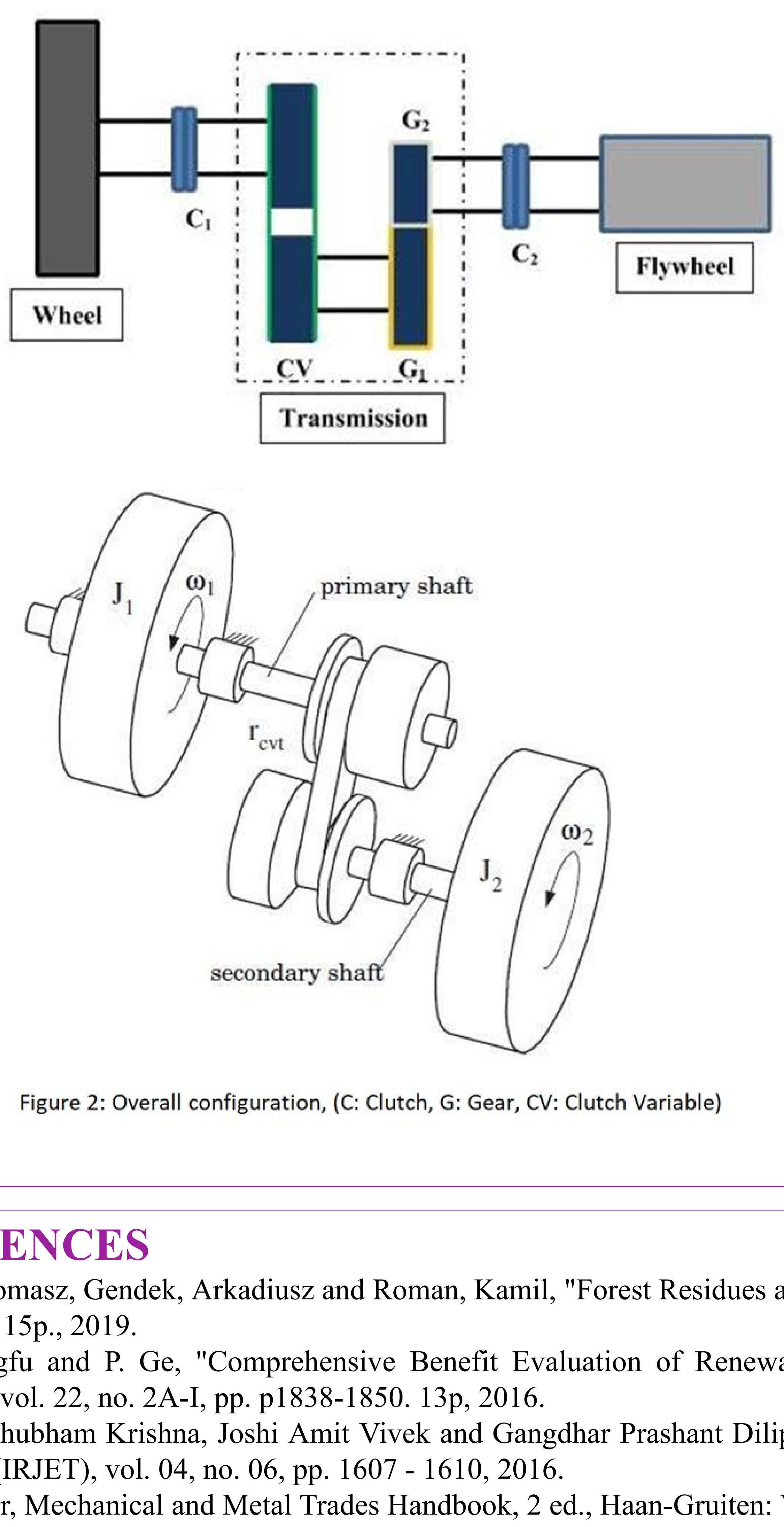

Figure 2: Overall configuration, (C: Clutch, G: Gear, CV: Clutch Variable)

FRICTION CALCULATION

The braking system mechanism is based on the friction between a disc and two pads. The disk is a rotating wear surface with a stationary pad. The following friction calculation as per [4] is as follows. The resulting friction force is dependent on the normal force F_N and the

- Type of type of friction, i.e. static, sliding, or rolling friction.
- Frictional condition / lubrication condition, i.e. dry, mix, or viscos friction.
- Surface roughness.
- Material pairing / material combination.

These effects are incorporated into the experimentally determined coefficient of friction μ.

Friction forces for static friction formula

$$F_F = \mu . F_N$$

Friction forces for rolling friction, which is caused by elastic deformation between rolling body and rolling surface.

$$F_F = \frac{f . F_N}{r}$$

Where, F_F friction force
F_N Normal force
μ coefficient of friction
f coefficient of rolling friction
r radius

FINAL CONCEPTUAL DESIGN

The concept of f-RBS is based on storing the rotational energy of the wheels and store it in the flywheel. Thus, if a mechanical variation is used for transmission, there will be no losses associated with the transformation of energy as energy is transmitted throughout in mechanical form. However, in many cases with energy storage flywheels and non-mechanical transmission, there are energy transformations and consequently the associated losses. [3]

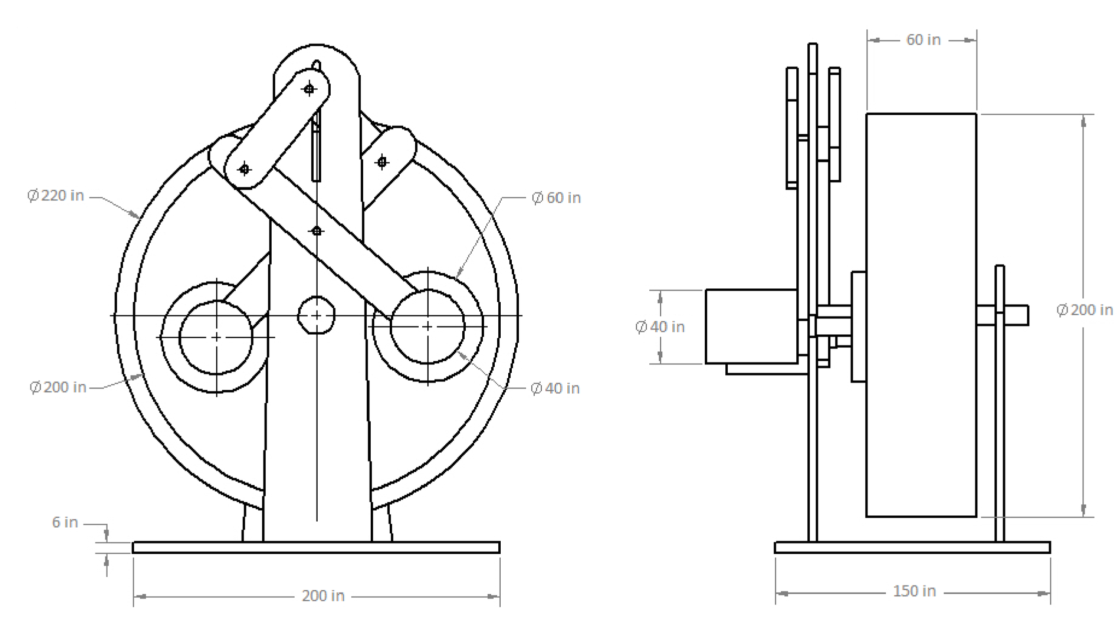

Figure 3: Front and side view of the Flywheel Regenerative Braking System

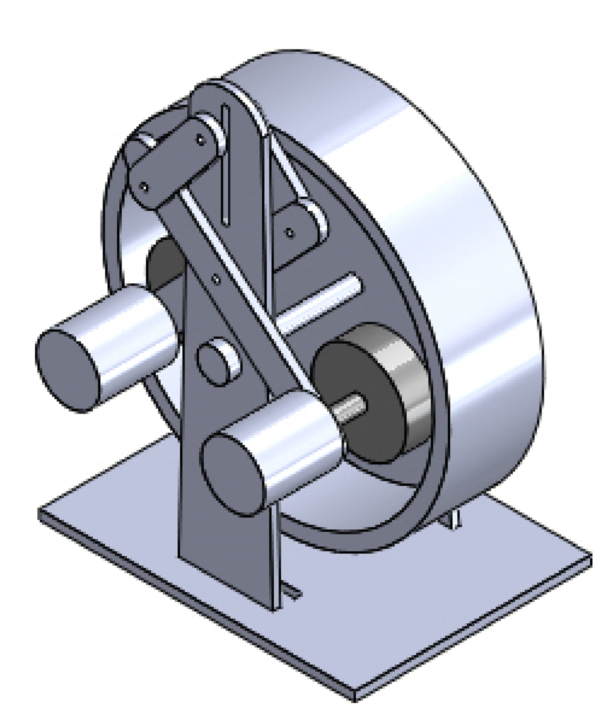

Figure 5: Isometric View of the Final Conceptual Design

CONCLUSIONS & FURTHER DEVELOPMENT

In this thesis, the design principles have been addressed. In addition, the mathematical model of the friction calculations have been derived. Areas of further developments which need to be addressed to scale up f-RBS :

1. Manufacture a composite-material flywheel to insure a high speed rotational dynamic.
2. Use some friction reduction methods like introduce bearing to the system.
3. Connect the system to a microcontroller unit to measure and analyse the outcome data.

REFERENCES

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